QPhysics
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Colloquium Notice

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Localization of light by disorder

Propagation of waves can be blocked and wave modes localized by disorder. First discovered for electrons at low temperatures, this “Anderson localization” takes place for other waves as well. Theoretical studies and experimental observations have been reported for sound and matter waves in various space dimensionalities, going from one-dimensional (1D) chains to three-dimensional (3D) bulk disordered materials. Interestingly, electromagnetic waves in general and light in particular seem to stand out from this general picture. First, the common belief is that Anderson localization is promoted by strong disorder. Localization of light, however, can be observed at weak disorder by confining light propagation to (quasi-)1D tubes or 2D planes but difficulties exist in 3D where even the strongest reachable disorder didn’t allow to demonstrate Anderson localization of light convincingly. Second, recent theoretical studies indicate that strong disorder seems to disadvantage localization by opening a new channel of wave transport involving non-propagating longitudinal fields. These fields are specific for electromagnetism and do not exist for scalar waves (sound or matter waves) or other vector waves (elastic waves in solids). Moreover, the point-scatterer model that allows for an exact solution, predicts diffuse scattering of light and exhibits no sign of localization at any disorder strength, even when the widely accepted Ioffe-Regel criterion of localization is obeyed by far. It seems therefore that in contrast to other waves, light can be localized by disorder in low-dimensional systems only, whereas a structured medium – a photonic crystal or a hyperuniform structure – is required to observe localization in 3D. In these latter materials, localization is expected to take place at weak disorder, similarly to low-dimensional systems and in agreement with the idea that strong disorder impedes the localization of light.

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